

# Low-energy limit of the radiative dipole strength in nuclei

Elena Litvinova<sup>1,2</sup>

<sup>1</sup>ExtreMe Matter Institute EMMI and Research Division, GSI; <sup>2</sup>National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824-1321, USA

We explain the upbend phenomenon, which was first reported in Ref. [1], later observed systematically in the  $\gamma$ -ray strength functions below neutron threshold of various light and medium-mass nuclei and probed by different experimental techniques [2]. Studies of Ref. [3] have revealed that this phenomenon, occurring in various astrophysical sites, can have a significant impact on their elemental abundances.

Phenomenological approaches approximate the  $\gamma$ -strength in this energy region by the tail of the giant dipole resonance with a temperature-dependent width. This is, however, absolutely not justified, because the low-lying  $\gamma$ -strength originates from underlying physics which is completely different from the giant vibrational motion. In addition, such approaches fail to reproduce the low-energy anomaly which is observed in medium-mass nuclei.

We propose a microscopic approach for the radiative strength function which is based on the statistical description of an excited compound nucleus. In it is shown [4] that the thermal mean field model provides a very reasonable approach to the compound nucleus. At the same time, it is simple enough to allow a straightforward generalization of very complicated microscopic approaches to nuclear response for the case of a compound nucleus, in terms of finite temperature corresponding to the nuclear excitation energy. To describe transitions from a thermally excited state, in the first approximation we employ the finite-temperature continuum QRPA developed in [5]. Variation  $\delta\mathcal{R}$  of the density matrix  $\mathcal{R}$  in the external field  $P$  obeys the following integral equation:

$$\delta\mathcal{R}(x; \omega, T) = \int dx' A(x, x'; \omega, T) \times \left( P(x') + \int dx'' F(x', x'') \delta\mathcal{R}(x''; \omega, T) \right), \quad (1)$$

where  $x = \{\mathbf{r}, s, \tau\}$ , and  $F(x, x')$  is the effective nucleon-nucleon interaction. The two-quasiparticle propagator  $A(x, x'; \omega, T)$  is calculated in terms of the Matsubara temperature Green functions in the coordinate space [5]. Its continuum part is responsible for transitions from the thermally unblocked discrete spectrum states to the continuum (see Fig. 1). The radiative dipole strength function is determined as:

$$f_{E1}(E_\gamma, T) = -\frac{16e^2}{27(\hbar c)^3} \text{Im} \int dx \delta\mathcal{R}_{E1}(x; \omega, T) P_{E1}(x), \quad (2)$$

$\omega = E_\gamma + i\Delta$ . Fig. 2 displays  $f_{E1}$  in  $^{94}\text{Mo}$  at the excitation energy around its neutron separation energy  $S_n$ , that represents the case of radiative thermal neutron capture,

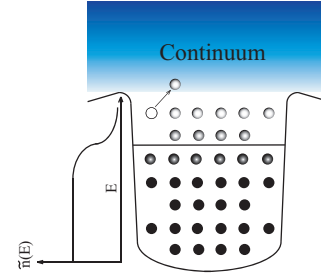


Figure 1: Schematic picture of the lowest-energy single-quasiparticle transitions from the thermally unblocked states with effective occupation probabilities  $\tilde{n}(E)$  to the continuum.

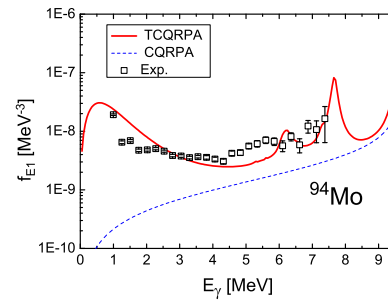


Figure 2: The  $E1$   $\gamma$ -strength for the thermally excited state of  $^{94}\text{Mo}$  near  $S_n$  (solid), compared to the strength for the ground state (dashed) and to Oslo data.

compared to  $f_{E1}$  in the ground state. The upbend of the strength due to the transitions illustrated schematically in Fig. 1 appears as a typical feature of  $\gamma$ -strength in medium mass nuclei while in heavy nuclei  $f_{E1}$  comes out rather flat at  $E_\gamma \rightarrow 0$ .

In conclusion, we explain the systematic low-energy enhancement of the  $\gamma$ -strength on the microscopic level and show that the approaches to r-process nucleosynthesis, involving Brink hypothesis, may need to be revised.

Support from Helmholtz Alliance EMMI is gratefully acknowledged.

## References

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